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Effects of Stress Upon Psychophysiological
Responses and Performance Following
Sleep Deprivation
(NAS 9-11753)

Final Report

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I

I. Introduction

The objective of this research was to determine the usefulness of psychological and physiological variables in predicting human performance under the stress of 48 hours of sleep deprivation. Prediction of performance decrement from physiological variables would be of obvious benefit to space crew monitors.

Additional objectives were to determine whether positive and negative feedback would differentially affect performance and whether four personality "types" respond differentially during sleep deprivation.

The four personality "types" selected to participate in this study were persons whose extreme scores on the ego strength scale of the Minnesota Multiphasic Personality Inventory (Barron, 1956) and on the extraversion scale of the Eysenck Personality Inventory (Eysenck and Eysenck, 1963) placed them in four quadrants defined by these scales. Groups defined by the ego strength scale had been shown to differ in both their initial level of performance and the amount of performance decrement they show after one night of sleep deprivation. Strausbaugh and Roessler, (1970) found persons who have high ego strength scores perform better initially and withstand the stress of one night's sleep deprivation better, as shown by less performance decrement, than persons who have low ego strength scores.

Although studies directly related to sleep deprivation that have used extraversion as a selection criteria are scarce, there are suggestive findings reported by Meyer et. al. (1970). Their study

used "extraverted athletes whose personalities were organized about the use of physical activity and self-assertiveness" (Type A) and "anxious, introverted, manifestly passive individuals, whose personalities were organized about intellectual achievement" (Type B) (p. 92). These two groups were significantly different on measures of systolic blood pressure decrease (type A greater decrease), of cognitive performance (greater improvement in type A) and, of affect (type A "unhappier" than type B). H. J. Eysenck (1970) reports studies which are interpreted to show that introverts and extraverts differ on at least two tasks (multiple reaction time and complex tracking) in the amount of deterioration of their performance due to sleep deprivation. On the basis of these reported results it was thought that the personality dimension of extraversion would be related to performance measures and possibly to physiological measures in this sleep deprivation study.

The performance measures taken during the 48 hours of sleep deprivation were selected to cover as wide a range of performance as possible.

These performance tests may be grouped according to the ability or faculty which contributes most to their scores. The Concept Acquisition, Reading Comprehension, Word Association, Word Memory, and Anagrams tests are related more to cognitive functioning than to perceptual or motor function. They involve problem solving, memory and associative functioning. The Stroop

Color Word test, Guilford-Zimmerman Spatial Orientation and Spatial Visualization require perceptual as well as cognitive functions. The Necker Cube and Time Perception tests more clearly require perceptual functioning only. The Pursuit Rotor and Vigilance task performance measures reflect motor functions in addition to perceptual processes. Appendix C contains a brief description of each performance measure. The physiological parameters which will be discussed later, were measured during the vigilance task. The tests of greatest interest were repeated in each period and therefore give a more complete picture of the performance changes which occurred across time. These measures will be emphasized in the following section dealing with the results of the experiment .

The physiological measures which were recorded during this study were 1) the phasic and tonic electrodermal measures, the Galvanic Skin Response (GSR) and Basal Skin Resistance (BSR), 2) heart rate, 3) respiration, and 4) plethysmographic finger pulse volume. Appendix D contains a detailed description of the methods employed to record these measures. It should be noted that considerable normal variation in these measures is due to circadian patterns in physiological activation levels (Froberg, Karlsson, Levi and Lidberg, 1970 and Schubert, 1969).

A total of 44 subjects were selected and tested for 48 hours due to data loss and requirements of the design, 32 subjects were included

in the final analyses. Of those 32 subjects, 8 were from each of the 4 groups formed on the basis of the Ego Strength and Extraversion scores; 1) High ego strength - high extraversion; 2) High ego strength - low extraversion; 3) Low ego strength - low extraversion; 4) Low ego strength - high extraversion. Subjects were scheduled in groups of 4, composed of a diverse assortment of subjects from each of the four personality groups, where possible one from each group. Scheduling problems, however resulted in only 3 of the 4 personality groups being represented in a majority of cases (6 of 11).

The subjects began their 48 hour period of sleep deprivation and performance at 6: 00 P. M. on a Friday evening. After the procedures and schedules were explained to each subject, he was given the consent form in Appendix A to sign. The 48 hours of sleep deprivation were divided into 6 periods of 8 hours each for the purposes of scheduling tests. All subjects could not be given the vigilance performance test at the same time. This necessitated a staggered order of testing within a group of 4 subjects. Appendix B contains a schedule of the actual test sequence for a group of 4 subjects. The periods were scheduled to result in 3 periods on day 1 which were comparable to 3 periods on day 2 with respect to circadian rhythms. The order of presentation of the Vigilance, Word Memory, Guilford-Zimmerman and Pursuit Rotor tests was counterbalanced between subjects within the 4 groups.

Effects of Sleep Deprivation:

Cognitive Measures:

The Word Memory task seems to be clearly a cognitive task. Subjects are required to listen to a recorded list of 25 words. The words are pronounced and spelled for the subject who writes the list during this presentation. After the list is presented and the subject's list is checked for correctness, the subject is asked to write as many words from the list as he can recall in 5 minutes.

Table 1 shows that the number of words correctly recalled decreased consistently across periods. This decrement in performance across time was differentially related to Ego Strength, although the analysis of variance interaction term (Groups x Periods) failed to achieve significance. The high Ego Strength subjects averaged 3.37 fewer words on their sixth trial than on their first trial, while low Ego Strength subjects averaged 4.56 fewer words in period 6 than period 1. Also the high Ego Strength group consistently recalled more words than the low Ego Strength group on all trials ($F=4.80$, $df 1/30$, $p < .05$). This effect of Ego Strength may be attributed primarily to those subjects in the high Ego Strength - high Extraversion grouping, who performed well from the outset and sustained their performance throughout the 48 hour session.

Reading comprehension was tested only three times during the 48 hour period, during the first, fourth, and sixth 8 hour periods. The reading comprehension scores cannot give as clear a picture

of the effects of 48 hours of sleep deprivation on cognitive function as do the word memory scores, but do support the decline in performance shown by the latter. The percentage of incorrect responses increased from 41.7 percent in period 1, to 48.8 percent in period 2 and to 51.6 percent in period 6. This decline was significant across periods ($F= 7.629$, $df 2/56$, $p. < .01$) but no meaningful group differences appeared in this measure ($F < 1.0$).

The Concept Acquisition Test involved two subtests presented in counterbalanced order in period 1 or 4. One subtest (conjunctive) required the subject to learn that the test card was a positive case if that card contained a particular geometrical figure with or without distractor items. The other subtest (disjunctive) required the subject to learn that a test card was a positive case if that card did not contain a particular geometrical figure. These two subtests were not of equal difficulty, the latter (disjunctive) subtest being more difficult than the former (conjunctive) subtest. The difficulty levels were counterbalanced between subjects, one-half receiving the conjunctive test first, and one-half the disjunctive test first. This procedure means that no subjects received the same type of test on day 1 as on day 2. The analysis of the number of attempts to identify the concept to be learned revealed a significant interaction of personality type, order of presentation of the two subtests and days ($F= 5.15$, $df 1/34$, $p. < .05$). The high Ego Strength - high Extraversion group improved in performance on both the disjunctive and the conjunctive tasks on day 2; while all other groups

failed to improve their performance when the disjunctive task was given on day 2.

The Anagrams tests seemed to be taken less seriously by the subjects than other formalized tests. Although the average number of anagrams solved decreased for all groups from day 1 to day 2 this result was far from consistent within subjects. Eighteen subjects solved fewer anagrams on day 2 while ten subjects solved more anagrams and four subjects solved an equal number on both days. In general the variability among the subjects seems to reflect their shifting motivation or attention to this task rather than any consistent pattern of performance decrement.

Perceptual-Cognitive Measures:

The Stroop Color-Word Test, the Spatial Orientation and the Spatial Visualization tests may be grouped for purposes of our discussion. These tests seem to fall into a mixed category of perceptual - cognitive function. They also all follow a similar trend across time in the 48 hour sleep deprivation session. The average score for subjects tends to improve slightly through the fourth period, then decline in period 5 and return to a 'normal' level in the last period. This decline may be attributed to the effect of circadian physiological rhythms. The same decline is not seen in period 2 performance because period 1 scores are depressed by the relative novelty of the situation. In general, the significant

term for periods in the analysis of variance performed on these scores is due, not to a consistent decrement of performance due to the stress of sleep deprivation, but rather to subjects being asked to perform the tasks during periods when their physiological functioning is normally depressed.

Perceptual - Motor Measures:

This same circadian effect may be seen in the perceptual-motor test scores. The Pursuit Rotor measure of performance, time on target, showed a slight increase through period 4. In period 5 the average time on target decreased below the level established in periods 3 and 4. This decline was transitory however as the average time on target returned to "normal" in period 6. The Vigilance task may also be considered a perceptual motor task. This Vigilance test yielded three measures which will be dealt with here, reaction time, percent error and interrogation rate. These measures all indicate that period 5 was the worst performance period of the 6. The longest reaction time, slowest interrogation rate and highest relative errors occurred in period 5. This decline in performance must be interpreted as being due to circadian physiological effects rather than specific sleep deprivation effects in view of the recovery of these measures in period 6. The recovery is not complete however, as can be seen from

Table 1, and suggests that extended sleep deprivation would cause further decrement in these performance measures.

Perceptual Tasks:

Three tests which are more clearly perceptual in nature are the Necker-Cube test, the Time Perception test, and a Memory For Faces test. There was no significant change in the Necker-Cube measures across periods, and no difference between day 1 and day 2 scores for either Time Perception or the Memory for Faces tests.

These performance measures may be characterized as showing minimal changes with this level of sleep deprivation. Those measures which do show a consistent trend across periods of deprivation are the more complex cognitive tasks. A definite circadian pattern is found in other measures which might be classed as less complex and more repetitive in nature. One of the tasks which reflects the effects of sleep deprivation, the Word Memory test, also shows differential performance levels for the high and low Ego Strength groups. There is not a significant interaction term of personality groups and periods of sleep deprivation however, which would indicate a differential stress tolerance. This failure of the interaction term to achieve significance may be attributed to the minimal stress developed by a 48 hour period of sleep deprivation.

Physiology:

Physiological measures which were taken during the vigilance task were heart rate, skin conductance (tonic), galvanic skin response (phasic), respiration, and finger pulse volume. The repetitive movements of subjects engaged in the Vigilance task caused difficulty with the respiration transducer resulting in artifacts and missing data. For this reason the respiration measures were not included in the analyses. Similar problems precluded any meaningful retrieval of the finger pulse volume data.

The analysis of the skin conductance and galvanic skin responses showed no significant trends related to length of sleep deprivation or to personality categories determined by Ego Strength or Extraversion scales in this sample. The heart rate measure only reflected the effect of first period novelty. These measures confirm the explanation of the relative stability of the performance measures as a lack of stress rather than compensatory effect.

Feedback Conditions:

In addition to the effects of sleep deprivation, the vigilance task was arranged to reflect the effects of two feedback conditions. For one-half of the vigilance period errors of omission or commission were signaled to the subjects by a brief electrical shock applied to their leg. This shock was not strong enough to be painful (@ 2 ma/cm²). It did provide an immediate feedback

however. The effect of this feedback was to improve performance. There was a significant decrease in reaction times, increase in interrogation rates, and decrease in total errors with feedback (see Table 3). The physiological parameters listed in Table 3 seem to show mixed effects of electrical shock. However, the elevated GSR response is a specific response to shock and does not reflect increased activation. That the true action of the shock was feedback rather than activation can be seen in the heart rate and skin conductance measures. These measures are not elevated significantly by the electrical shock.

Although the majority of the performance measures which were significantly impaired followed a circadian pattern, it seemed reasonable to attempt, by means of a multiple correlation-regression analysis (Dixon, 1971), to develop an equation for our sample to predict their level of errors on the vigilance task. This rate of errors measure was selected as being most likely to reflect the "lapses" or momentary failures to attend which were described by Williams et. al. (1959). In an effort to provide some check on the reliability of any equation which might be generated, two groups of subjects were used. One-half of the subjects who made the fewest errors on the vigilance task were designated "good performers", the other half of the subjects were designated "poor performers". Two groups were formed that each contained an equal number of good and poor performers. The multiple regression equation was

developed on one of the two groups and checked against the same program run on the second group. The result of this procedure was the identification of ten items or measures which together account for over 90 percent of the variability of subjects' error scores on the last period of sleep deprivation (period 6). These predictive measures are of three types:

1. Personality Measures: Ego Strength scores, Extraversion scores, and the K scale from the MMPI.
2. Performance Measures (from period 1): Average Reaction Time, Average Interrogation Rate, and Average Percent Error (again from the initial period).
3. Physiological Measures: Skin Conductance and Heart Rate (from the preceding period 5 and from the period of performance being predicted).

Although these measures do account for a significant percentage of the variance of period 6 vigilance error scores in both of the artificial groups established for this analysis, the weights developed for each measure are not similar enough in the two samples to justify any attempts at generalization to other samples.

Conclusions:

The pattern of performance changes observed in these subjects over 48 hours of sleep deprivation generally fit a circadian pattern

i. e. , the changes are not due to the stress of sleep deprivation. Rather, they are the result of testing subjects at times when they would normally have been asleep. This effect of time of testing is more apparent on the second day as most measures are significantly changed in period 5 (2 A. M. to 10 A. M. , second day). The exception to this pattern are the word memory scores which deteriorate consistently across periods. The reading comprehension scores, although not as frequently measured, also show a consistent decrement. These findings are consistent with reports that cognitive functioning is most readily affected by sleep loss (Fiorica, et. al, 1970), while physiological and behavioral functions requiring a lesser amount of cerebral integration are more resistant to the effects of sleeplessness. In order to produce a level of stress sufficient to produce changes in simple or well-learned tasks and hopefully , in associated physiological parameters in a subject population of young males a period of sleep deprivation longer than 48 hours must be maintained. The generally non-significant findings regarding the relationships of physiological parameters and performance measures in this study must be attributed to a failure to produce sufficient sleep loss to cause performance decrement. This same reasoning applies to the indistinguishability of personality groups established by the ego strength and extraversion measures. Differential responses to

stress depends on the production of stress of sufficient magnitude to be reflected in performance or physiological responses.

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TABLE 1 - Performance Measures Across Periods Of Sleep Deprivation

Performance Term	P 1	P 2	P 3	P 4	P 5	P 6	p
Word Memory - mean # right	20.47	19.59	18.91	18.34	17.44	16.50	* *
Reading Comprehension - % error	41.72			48.84		51.63	* *
Concept Acquisition - attempts conjunctive task	33.00			46.00			* *
disjunctive task	8.00			16.00			* *
Anagrams - # right		11.34			10.62		
Stroop - total time	98.44	93.00	92.50	90.47	94.09	90.75	* *
Guilford-Zimmerman							
Spatial Orientation - # right	27.75	29.59	31.41	32.59	23.22	26.34	* *
Spatial Visualization - # right	24.13	25.00	25.72	27.09	22.72	24.41	*
Pursuit Rotor (45) - time on target	16.27	17.39	18.04	18.20	17.74	18.09	* *
Pursuit Rotor (60) - time on target	12.82	14.85	16.27	16.52	15.47	17.01	* *
Reaction Time - mean	1.13	1.14	1.12	1.12	1.18	1.15	*
Interrogation Rate - mean	144.22	141.21	142.85	147.66	132.52	138.94	*
Omission Error (%)	31.44	33.59	28.53	27.78	38.17	35.50	* *
Necker Cube - # reversals	18.06	16.63	16.75	16.44	15.59	15.31	
Time Perception - mean absolute error			7.26			5.10	
Memory for Faces			11.59			11.41	

* * p < .01
* * p < .05

TABLE 2 - Physiology Measures Across Periods

Measure	P 1	P 2	P 3	P 4	P 5	P 6	p
Galvanic Skin Response	1.05	1.97	1.01	1.09	1.30	1.04	NS
Skin Conductance (Tonic)	40.43	49.92	42.94	44.10	38.29	51.51	NS
Heart Rate (beats per minute)	94.12	84.93	85.20	86.96	80.56	82.80	* *

* * p < .01

NS p > .05

TABLE 3 - Feedback Conditions & Performance Levels

	No		
	Shock	Shock	p
RT	1.12	1.15	* *
IR	143.08	139.39	* *
% Error	30.55	34.35	* *
HR	86.11	85.41	NS
SC	45.51	43.55	NS
GSR	1.65	.84	* *

NS p > .05

* * p < .01

PERMISSION FORM

I hereby agree to participate in this study designed to test the effect of 48 hours sleep deprivation on performance measures being conducted by Robert Roessler, M. D. I do so with the understanding that:

- a) I will be required to perform various perceptual and perceptual-motor tasks, one of which includes electrical shock as a part of the task contingencies,
- b) Various personality and ability tests and questionnaires are to be completed as part of this study and that these test results are to be confidential and are to be used only for research purposes,
- c) Physiological parameters are to be monitored during repeated performance testing and the electrodes applied for this purpose and those used to administer the electrical shocks may, in some cases, cause local skin irritation when worn for as long as 48 hours,
- d) I may withdraw from the study at any time,
- e) I will be paid only upon completion of all tests and tasks and after meeting all requirements of the experiment,
- f) The withdrawal of any subject may result in dismissal of all subjects in his group or session of the experiment.

The above statements have been explained to me to my satisfaction and the rate of remuneration for completing my duties (\$100.00) is satisfactory to me.

WITNESS

SUBJECT

SUBJECT'S SS#

ADDRESS

DATE

This verifies that I did participate in a 48 hour sleep deprivation study on _____. I understand that I will be paid \$100.00 for my participation in this study.

WITNESS

SIGNATURE

APPENDIX B (continued)

Periods 2 & 5 (2A. M. - 10 A. M.)

<u>Subject A</u>	<u>Subject B</u>	<u>Subject C</u>	<u>Subject D</u>
Card Sorting	Electrodes Checked	Card Sorting	Electrodes Checked
Electrodes Checked	Card Sorting	Electrodes Checked	Card Sorting
Vigilance - Shock	Stroop Color-Word Test	Anagram	Anagram
Avoidance Test	Necker-Cube Test	Lists	Lists
Word Memory Test	Vigilance - Shock		Stroop Color-Word Test
Guilford Zimmerman	Avoidance Test	Vigilance - Shock	Necker-Cube Test
Spatial Orientation	Word Memory Test	Avoidance Test	Vigilance - Shock
Spatial Visualization	Guilford Zimmerman	Word Memory	Avoidance Test
Pursuit Rotor Tests	Spatial Orientation	Guilford Zimmerman	Word Memory Test
Stroop Color-Word Test	Spatial Visualization	Spatial Orientation	Guilford Zimmerman
Necker-Cube Tube	Pursuit Rotor Test	Spatial Visualization	Spatial Orientation
Anagram	Anagram	Pursuit Rotor Test	Spatial Visualization
Lists	Lists	Stroop Color-Word Test	Pursuit Rotor Test

-Half Hour Break - All Subjects - Light Meal & Rest-

Periods 2 & 5 - Holtzman Ink Blot Test - Forms A & B - All Subjects

Period 2 - Minnesota Multi-phasic Personality Inventory - All Subjects

Period 5 - California Personality Inventory - All Subjects

Fifteen Minute Break For Personal Hygiene - All Subjects

APPENDIX B (continued)

Periods 3 & 6 (10 A. M. - 6 P. M.)

<u>Subject A</u>	<u>Subject B</u>	<u>Subject C</u>	<u>Subject D</u>
Scrabble Game w/C	Electrode Application	Scrabble Game w/A	Electrode Application
Electrode Application	Scrabble Game w/D	Electrode Application	Scrabble Game w/B
Vigilance - Shock	Stroop Color-Word Test	Thematic Apperception Test	Thematic Apperception Test
Avoidance Test	Necker-Cube Test		
Word Memory Test	Vigilance - Shock		Stroop Color-Word Test
Guilford-Zimmerman	Avoidance Test	Vigilance - Shock	Necker-Cube Test
Spatial Orientation	Word Memory Test	Avoidance Test	Vigilance - Shock
Spatial Visualization	Guilford-Zimmerman	Word Memory Test	Avoidance Test
Pursuit Rotor Test	Spatial Orientation	Guilford-Zimmerman	Word Memory Test
Stroop Color-Word Test	Spatial Visualization	Spatial Orientation	Guilford-Zimmerman
Necker-Cube Test	Pursuit Rotor Test	Spatial Visualization	Spatial Orientation
Thematic Apperception Test	Thematic Apperception Test	Pursuit Rotor Test	Spatial Visualization
		Stroop Color-Word Test	Spatial Visualization
		Necker-Cube Test	Pursuit Rotor Test

-Half Hour Break - All Subjects - Light Meal & Rest-

Period 3 - Schedule of Recent Experiences - All Subjects	Number Facility Test	Number Facility Test	Number Facility Test
Period 6 - Reading Comprehension Test - All Subjects	Time Perception Test	Time Perception Test	Time Perception Test
Number Facility Test	Memory for Faces Test	Rod & Frame Test	Memory for Faces Test
Time Perception Test	Rod & Frame Test	Memory for Faces Test	Rod & Frame Test
Rod & Frame Test	Memory for Faces Test		
Memory for Faces Test			
Period 6 - Zuckerman Mood Schedule - All Subjects			
Period 6 - Reaction to Experiment Questionnaire - All Subjects			
Period 6 - Post-Experiment Interview - All Subjects			

APPENDIX C

Test Descriptions and Examples

The Vigilance task requires the subject to monitor three meters for deflections of an indicator needle. Each meter must be interrogated or checked by depressing a corresponding green button below that meter on the display module. If a deflection is detected the subject must depress a red button below the interrogation button. Errors are scored if the subject does not depress the red button within 1.5 sec. after the meter deflection onset (omission error) and, if the subject depresses the red button when no deflection has occurred (commission error). During one-half of each vigilance performance period (11 of 22 minutes) an error resulted in the subject's receiving a brief electrical shock (2 milliamps/cm²). Measures of interrogation rate and the reaction time on each deflection were recorded during this task.

Word Memory testing required the subject to listen to a tape of 25 words pronounced and spelled for him. The subject was required to write the list while listening to the tape. At the end of the tape, the subject's written list was checked for accuracy and any mistakes were corrected for him. He was then given 5 minutes in which to write down as many words on the list as possible.

The Guilford-Zimmerman tests are composed of two types of items. The Spatial Orientation test requires subjects to visualize what change has occurred in the relative positions and attitudes of a boat's prow and a shoreline, shown in two drawings. The subject must analyze the two drawings to determine which of 4 possible answers corresponds to the movement of the boat necessary to translate the scene from the first drawing into that scene depicted in the second. The Spatial Visualization test has the subject mentally maneuver a clock through movements in three dimensions and select from among four alternatives the one which corresponds to the final position of the clock.

The Pursuit Rotor task involves tracking a small metal disc on a turntable with a handhelp stylus. So long as the turntable is spinning the subject attempts to hold the stylus on the metal disc. The duration of each contact and the number of such contacts is automatically recorded.

The Color-Word test consisted of seven cards on 6 of which a list of color names were printed. One card had a column of colored squares down its center. The subject's task on the four test cards was to name the color in which a color name was printed. For example, the color name "blue" might be printed in brown ink, the subject was required to respond "brown". Each card had twenty such items composed of various combinations of brown, red, blue, green, and orange ink and the appropriate (or inappropriate) color names. In order to respond correctly to each item the subject must inhibit his natural inclination to read the word. Control cards merely had to be read aloud. (For more information see Dalrymple-Alford and Budayr, 1966)

The Necker cube is a skeletal cube drawing which may be perceived in one of two orientations (i. e., it is a reversible figure). The subjects were instructed to report each reversal of perspective in the cube for one minute by pressing the switch on a counter. (Wieland and Mefferd)

Two word lists were used in the Word Association testing. They were each composed of 48 words taken from a list developed by Mefferd and Moran.

The Reading Comprehension tests were three subsections from a sample Graduate Record Examination. They were judged to be difficult enough to challenge the college population tested.

The Rod and Frame test consists of a series of judgements by the subject of the orientation of a rod. The subject's task is to orient the rod to the upright. A square frame around the rod at the end of a viewing tunnel may be tilted from an upright position as much as 28 degrees. The amount of error in the orientation of the rod to the true upright is taken to be a measure of Field Dependence-Independence (Witkin, 1954).

Concept Acquisition involves the subjects' deriving a rule for set membership or inclusion in a group of positive cases. For example, a conjunctive concept rule might be to include those instances in which a card contains a particular geometrical figure. A disjunctive concept rule requires the subject to include any instance where a particular figure does not appear on a card. Feedback, after each card has been excluded or included, as to whether that card is a positive or negative case allows the subject eventually to verbalize the requirements of set membership and solve the problem.

The card sorting task had each subject sort a stack of computer cards on four digits in a short period of time.

The list of Anagrams and solutions are included at the end of this Appendix.

The Holtzman Ink Blots are similar to Rorschach ink blots but are adopted to group administration. These data were not scored. (Holtzman, Thorpe, Swartz & Herron, 1961)

The Minnesota Multiphasic Personality Inventory has been extensively described elsewhere. (Dahlstrom & Welsh, 1962)

The California Personality Inventory, like the Minnesota Multiphasic Personality Inventory, is a sequence of statements to be ranked as true or false by the subject with regard to whether the statements are descriptive of him. (Gough, 1964)

The Thematic Apperception Test consists of pictures or drawings of ambiguous scenes. The subjects' task is to "tell a story" about the scene in the picture. These stories may be scored for measures of need achievement or motivation level. (Morgan and Murray, 1935, Atkinson & McClelland, 1948)

The Schedule of Recent Experience (Rohe, Meyer, Smith, Kjaer, and Holmes, 1964) is a scale developed to measure the amount of life change a person has undergone in a given period. These changes are rated according to the amount of stress they produce. A high scale value is expected to be related to or predict illness.

Number Facility was a series of addition problems performed under time pressure and scored from accuracy and speed.

Time Perception was an estimation task. Subjects were asked to estimate in seconds the length of an interval between two spoken cues.

Memory for Faces testing had the subjects view one of two matrices of pictures of 16 peoples faces for one minute. At the end of one minute the subject was asked to indicate which of the 16 faces were repeated in a larger (32 pictures) matrix.

APPENDIX C

ANAGRAMS I

MYRIG _____

TOBEG _____

VEECAL _____

HIWALE _____

TUNOF _____

KEROP _____

DYOMLE _____

BUHLEM _____

LAMBY _____

YONPE _____

GLOBON _____

LAIHNE _____

FITEB _____

VOLCE _____

DOCEED _____

ENTINY _____

RAAMO _____

CALVO _____

TEMRIP _____

EMBURP _____

APPENDIX C

ANAGRAMS II

YIEPT _____

OIXED _____

CEADAR _____

ETOLAC _____

IFFYT _____

DYMAL _____

SATHAG _____

WHENEP _____

FREGI _____

WROPE _____

GREdle _____

NIGINN _____

URIOC _____

TYDIT _____

CHENUQ _____

GANBIK _____

CALLI _____

KNUSK _____

MALOTS _____

CREFDO _____

APPENDIX C

ANAGRAM ANSWERS

ANAGRAMS I

GRIMY
BEGOT
CLEAVE
AWHILE
FOUNT
POKER
MELODY
HUMBLE
BALMY
PEONY
OBLONG
INHALE
BEFIT
CLOVE
DECODE
NINETY
AROMA
VOCAL
PERMIT
BUMPER

ANAGRAMS II

PIETY
OXIDE
ARCADE
LOCATE
FIFTY
MADLY
AGHAST
NEPHEW
GRIEF
POWER
LEDGER
INNING
CURIO
DITTY
QUENCH
BAKING
LILAC
SKUNK
ALMOST
FORCED

Subject No. _____

Run _____

Sleep Questionnaire B

NAME: _____

DATE: _____

1. Describe the quality of your sleep last night. If poor or unusual, tell why it was so.

2. How many hours did you sleep? _____
3. How long did it take for you to go to sleep? (minutes) _____
4. Did you awaken during the night? _____
5. How many times did you awaken? How long were you awake and approximately what part of the night did the awakening(s) occur? _____

6. Were you ever awake and unable to return to sleep for a considerable period of time? How long was the period? _____
7. If you awakened, how difficult was it to go back to sleep? (check one)
No difficulty () Very little difficulty ()
Considerable difficulty ()
Not able to ()
8. How much difficulty did you have in falling asleep initially?
No difficulty () Very little difficulty ()
Quite a bit of difficulty ()
Much difficulty ()
9. How rested do you feel this A. M. ?
Very rested ()
Moderately rested ()
Not very rested ()
Not rested at all ()
10. How much did you enjoy your sleep?
Much enjoyment ()
Moderate enjoyment ()
Little enjoyment ()
No enjoyment ()
11. Do you remember dreaming? If so, tell how many dreams you had and briefly describe the content of the dreams. _____

Run # _____
Record # _____
Time _____

1. NAME: _____ AGE: _____
2. DATE: _____
3. Are you now suffering, or have you suffered from any acute illness today or during the past week? (Include minor illnesses such as "flu", colds, allergies - no matter how minor.) _____

4. Have you taken any medication in the past 48 hours? If yes, list the drug(s) and dosage (include such ordinary drugs as aspirin, antihistamines, vitamins, etc.) _____

5. How many cups of coffee, if any, did you drink today? _____
6. Do you use alcohol in any form? _____ Have you had any in the past 24 hours? _____
If yes, how much? _____
7. Did you smoke today? If yes, what and how much? _____
8. Have any unusual events occurred in your life during the past week and/or are you anticipating anything unusual? (Pleasant, unpleasant or neutral - e.g., financial problems, unexpected good fortune, difficulty in one of your courses, a fight with your girl friend, etc.) If yes, briefly describe. _____

9. Has anything upset you today (usual or unusual)? If yes, describe briefly how you felt and what it was that disturbed you. _____

10. Have you ever had any serious illness? If so, what and when? _____

11. When did you last see a doctor? For what reason did you see him? _____

12. Did you sleep well last night? _____ How many hours? _____
13. What is the highest grade you have completed in school? _____
14. Are you continuing your education? _____ Where? _____

APPENDIX C

- 1 active
- 2 adventurous
- 3 affectionate
- 4 afraid
- 5 agitated
- 6 agreeable
- 7 aggressive
- 8 alive
- 9 alone
- 10 amiable
- 11 amused
- 12 angry
- 13 annoyed
- 14 awful
- 15 bashful
- 16 bitter
- 17 blue
- 18 bored
- 19 calm
- 20 cautious
- 21 cheerful
- 22 clean
- 23 complaining
- 24 contented
- 25 contrary
- 26 cool
- 27 cooperative
- 28 critical
- 29 cross
- 30 cruel
- 31 daring
- 32 desperate
- 33 destroyed
- 34 devoted
- 35 disagreeable
- 36 discontented
- 37 discouraged
- 38 disgusted
- 39 displeased
- 40 energetic
- 41 enraged
- 42 enthusiastic
- 43 fearful
- 44 fine
- 45 fit
- 46 forlorn
- 47 frank
- 48 free
- 49 friendly
- 50 frightened
- 51 furious
- 52 gay
- 53 gentle
- 54 glad
- 55 gloomy
- 56 good
- 57 good-natured
- 58 grim
- 59 happy
- 60 healthy
- 61 hopeless
- 62 hostile
- 63 impatient
- 64 incensed
- 65 indignant
- 66 inspired
- 67 interested
- 68 irritated
- 69 jealous
- 70 joyful
- 71 kindly
- 72 lonely
- 73 lost
- 74 loving
- 75 low
- 76 lucky
- 77 mad
- 78 mean
- 79 meek
- 80 merry
- 81 mild
- 82 miserable
- 83 nervous
- 84 obliging
- 85 offended
- 86 outraged
- 87 panicky
- 88 patient
- 89 peaceful
- 90 pleased
- 91 pleasant
- 92 polite
- 93 powerful
- 94 quiet
- 95 reckless
- 96 rejected
- 97 rough
- 98 sad
- 99 safe
- 100 satisfied
- 101 secure
- 102 shaky
- 103 shy
- 104 soothed
- 105 steady
- 106 stubborn
- 107 stormy
- 108 strong
- 109 suffering
- 110 sullen
- 111 sunk
- 112 sympathetic
- 113 tame
- 114 tender
- 115 tense
- 116 terrible
- 117 terrified
- 118 thoughtful
- 119 timid
- 120 tormented
- 121 understanding
- 122 unhappy
- 123 unsociable
- 124 upset
- 125 vexed
- 126 warm
- 127 whole
- 128 wild
- 129 willful
- 130 wilted
- 131 worrying
- 132 young

APPENDIX D: Physiology Measures

Electrodermal measures were taken from the palmar surface of the middle phalanx of the middle finger of the subject's non-preferred hand. The site was cleaned with acetone, coated with electrode paste (See Edelberg, Greiner, and Burch, 1960) and a 2 cm² silver-silver chloride active electrode was applied. The indifferent electrode was a 10 x 7.5 cm. silver-silver chloride plate on the volar surface of the forearm of the non-preferred hand. A constant current of 10 microamp/cm² was applied through the active electrode. The direct current signal was amplified by a Biophysical Research Instruments Model 605 amplifier and this signal was digitized by an Electronics Laboratories, Inc. Model 301 G.S.R. Analyzer and a Model 302 B.S.R. Analyzer. The digital signal was recorded on a Digi-Data Corporation magnetic tape recorder. The resistance values for the basal or tonic measure is converted to skin conductance values (micromhos) by a general purpose computer.

Electrocardiogram was recorded from a standard Lead II configuration using 2.0 cm² silver-silver chloride electrodes using the same electrode paste employed for skin resistance. The signal was amplified through a Model 612C Biophysical Research Instruments (BPRI) amplifier and then analyzed by a Model 306 Electronics Laboratories, Inc. (ELI) R-R interval analyzer accurate to the nearest millisecond.

Respiration measures were taken from the resistance changes in a mercury filled tube placed around the subject just below the level of the diaphragm. Inspiration stretched the tube and decreased the diameter of the mercury column thereby increasing the resistance to current applied across the tube. These resistance changes were amplified by a Model 616 BPRI amplifier and then analyzed by a Model 303 ELI respiration analyzer. The digitized signal was recorded on magnetic tape.

The Finger Pulse Volume was measured by a Model 621 BPRI Plethysmographic Transducer which employs a transilluminating photoplethysmographic finger cuff to measure changes in blood flow. The transducer was applied to the third or ring finger of the subject's non-preferred hand and secured by an arrangement of velcro strips attached at the wrist. The signal was amplified by a Model 616 BPRI amplifier and analyzed by a Model 304 ELI Plethysmography Pulse Analyzer. These digital signals were also recorded on magnetic tape.